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TEST REPORT OF Mk 45 AND Mk 47 SHAPED DEMOLITION CHARGES COMPATIBILTY TESTING

John G. Seubert

Naval Ammunition Depot
Crane, Indiana

24 July 1973

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TEST REPORT
OF
MK 45 AND MK 47
SHAPED DEMOLITION CHARGES
COMPATIBILITY TESTING

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a. The RDX composition is incompatible with the adhesives,

b. The charges are presently safe.

c. The designs will not rapidly deteriorate to an unsafe condition,

d. The charges currently meet the original design requirements.

Details of illustrations in this document may be better studied on microfiche.

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Mk 45 and Mk 47 Shaped Demolition Charges were tested to determine the safety of the designs and the effects of the incompatibility between the RDX composition and the adhesives. The testing verified the following:

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BACKGROUND: Preliminary testing of Mk 47 charges and MIL-A-5072 rubber adhesive by NWS Yorktown indicated that the RDX composition (97% RDX, 2% Wax, and 1% Graphite) and the rubber adhesive were incompatible. In order to determine the effects of this incompatibility on the safety, performance and use of the charge, a test program was conducted.

DESCRIPTION: The test program consisted of a combination of safety, performance and laboratory tests. A total of sixty charges were tested, forty MK 47 Mod 0 charges manufactured September 1971 and twenty Mk 45 Mod 0 charges manufactured February 1969. The charges were tested in accordance with the test outline, figure 1. The composition samples were tested in accordance with the test schedule of Table I. The Mk 45 charges were tested to determine if there was an aging factor as they were 31 months older and would show more pronounced effects than the Mk 47 charges.

TESTING: The testing program was conducted in four phases; I - Safety Drop Series, II - Laboratory Tests, III - Temperature and Humidity - Drop Series, and IV - Control Tests.

I. Safety Drop Series

The first phase of the test program consisted of a safety test sequence followed by an additional drop test. The purpose of this phase was to verify the immediate safety of the charges and to obtain samples of the RDX composition for the second phase of the program. The safety test sequence consisted of first conditioning the unit at 160°F for 16 to 30 hours, then subjecting it to 40 ft. Drop, MIL STD 331, Test 103, in the horizontal position while at 160°F. The additional drops were at 60 or 88 feet, as detailed in Table II. All charges were satisfactory, i.e., no explosive or burning reaction occurred. Three Mk 47 charges and all the Mk 45 charges broke apart and were used for the samples of Phase II. Figure 2 shows the dark discoloration (left center) of the RDX composition that had been in contact with the rubber adhesive and figure 3 shows the discoloration (top left corner) resulting from exposure to the epoxy.

Seven of the Mk 47 charge cases were intact, although the detonator holders were broken off four units, after the drop series, figures 4 and 5, and were used for penetration testing. The charges were tested without the base socket. Three of these charges had received internal damage that resulted in considerably reduced penetration, 3.55 in., 3.76 in., and 4.97 in. The penetration of these charges and other subsequent damaged charges was characterized by irregularity in the entrance hole, an indication of cone deformation. The balance of these units functioned with an average penetration of 7.04 inches with two units exceeding the required depth of 7.25 inches.

II. Laboratory Tests

The second phase of the test program consisted of the preparation of 17 test samples, A through Q, and the testing of these samples to determine the impact sensitivity, vacuum stability, differential thermal analysis and the differential scanning calorimetry. The impact sensitivity test was performed in accordance with OD-44811, the results are detailed in Table III. The impact sensitivity test data is compared with that of recrystallized TNT, tetryl and RDX rather than the lead styphnate and dextrinated lead azide as indicated in OD-44811, paragraph 1.4.2. The samples did not exhibit any increase in sensitivity and the decreased sensitivity of samples B and O would not affect overall performance in that the detonation originates in the booster cup and not at the material interfaces. The vacuum stability tests were performed in triplicate in accordance with OD-44811, the results are detailed in Table IV. The formula used to calculate the volume of gas evolved during the test was corrected as follows:

$$V = \frac{(A+CB)273(P)}{760(273+t)} - \frac{(A+CB_1)273(P_1)}{760(273+t_1)}$$

where B = Length of capillary from heating tube joint to top of mercury column at end of test in mm.

B_1 = Length of capillary from heating tube joint to top of mercury column at beginning of test in mm.

A, C, P, V, t, P_1, t_1 are the same as OD 44811

The first samples containing the A-12 epoxy, F and H, evolved excessive gas volumes (33-43 ml). This obvious incompatibility negated the need and additional cost of testing samples G, N, and O. Sample C, rubber adhesive, evolved an average of 3.57 ml. Mixtures of sample C with the RDX composition with original rubber adhesive evolved a maximum of 2.0 ml with the Mk 45 material, sample B, and a maximum of 2.9 ml with the Mk 47 material, sample K. The differential thermal analysis (DTA) was performed in accordance with standard laboratory procedure using a Dupont 900 DTA at a scan rate of 15°C per minute. The sample size used was 2.0 mg compared against an aluminum oxide reference. The test was conducted using an ambient air atmosphere. The data is presented with a vertical scale of 50°C per inch and compared to a laboratory standard of RDX in order to compare several samples each tract is displaced from the proceeding. Figures 6-9 show typical DTA curves of the test samples. Samples with new rubber adhesive, B, D, K and L, show a slight decrease in the ignition temperature from 245°C to 225°C. The samples with new epoxy (F, G, H, and O) show a significant change from the standard RDX with the elimination of the ignition exotherm. The sample N showed a lowering of the ignition temperature to about 200°C. The RDX compositions all differed from the RDX standard in that the exothermic spike at 190°C is moderated and biforcated by the wax binder utilized in the RDX composition. The differential scanning calorimetry (DSC) testing was performed in accordance with standard laboratory procedures using a Perkin Elmer DSC-1-B at a heating rate of 10°C per minute. The samples were tested under a nitrogen atmosphere with a flow rate of 24 cc. per minute. The range attenuation was 32 (64 millicalories per second) and the chart speed was 1 inch per minute. The slope was adjusted to 540. The temperature calibration was at 270 degrees average and 510 degrees differential. The heat of decomposition of the samples is detailed in Table V. The 50-50 rubber adhesive-RDX composition samples (B, D, K and L) exhibited a significant increase in the heat of decomposition, as would be predicted based on the heat of decomposition for rubber of 3000. The decreased values for samples with the epoxy adhesive (F, H, I, O, and P) is attributable to the lower heat of decomposition of the epoxy. Figures 10-13 show typical DSC curves of the test samples. Again as in the DTA, the samples with new rubber adhesive (B, D, K and L) show a decrease in the decomposition temperature. The samples with the new epoxy (F, G, H, N and O) show that the decomposition peaks were significantly changed. The samples from the charges (A, E, I, J, M and P) were quite similar to the standard RDX.

III. Temperature and Humidity - Drop Series

The third phase of the testing program consisted of first conditioning 10 Mk 47 charges each to 14 days and 28 days of temperature and humidity (T&H) cycling. The T&H cycling was in accordance with MIL-STD 331, test 105, except that all weekends were at 160°F. The charges were then subjected to the safety test sequence of Phase I. The purpose of this phase of the program was to determine if aging of the charges would either jeopardize the safety or reduce the penetration performance. Both the 14 and 28 day T&H series test units were satisfactory in regards to both safety and performance. Forty foot drop of the 14 day T&H units resulted to two units breaking apart and the detonator holder separating from the case of three other charges. Forty foot drop of the 28 day T&H units resulted in two units breaking apart and the detonator holder separating from the case of five other charges, figures 14 and 15. The copper cones of the units that broke apart were darkened and discolored as depicted in figure 16. The phase three charges were tested without the base sockets, the test results are detailed in Table VI. One unit from each of the series tests received internal damage that resulted in reduced penetration and one unit from the 28 day T&H series resulted in fracturing of the charge case when initiation was attempted. The 14 day T&H series resulted in an average penetration of 7.31 inches with five units exceeding the required depth of 7.25 inches. The 28 day T&H series resulted in an average penetration of 7.46 inches with six units exceeding the required depth of 7.25 inches.

IV. Control Tests

The fourth phase of the test program consisted of penetration performance tests to assess the present ability of the charges to achieve the desired penetration. Ten charges of each design were tested for penetration. The test results are detailed in Table VII (note the Mk 47 charges were tested without the base sockets). The Mk 45 charges had an average penetration of 4.56 inches with all units exceeding the required 4.0 inches. The Mk 47 charges had an average penetration of 7.59 inches with all units exceeding the required 7.25 inches.

CONCLUSIONS

A. The first phase of the test program verified that both the Mk 45 and Mk 47 Shaped Demolition Charges are safe to handle and use.

B. The second phase of the test program verified that there is a compatibility problem. Both the rubber adhesive, MIL-A-5072, and the epoxy, Armstrong A-12, are incompatible with the RDX composition. Although there are no safety problems resulting from this incompatibility, the laboratory tests indicate that there is sufficient inter-reaction to justify redesign and elimination of the incompatible adhesives.

C. The third phase of the test program verified that the charges will not rapidly deteriorate to an unsafe condition due to the incompatibility. Based on the successful completion of the drop series after both 14 and 28 day temperature and humidity cycle, the charges should continue to be safe for at least two years.

D. The fourth phase of the test program verified that the charges are capable of achieving the required penetration depths. Comparison of the average penetrations obtained throughout the program, Table VIII, with the original penetrations obtained during the design evaluations, 7.95 inches Mk 47 (bakelite case) and 4.4 inches Mk 45, indicate that the charges will continue to meet the original design requirements.

FIGURE 1

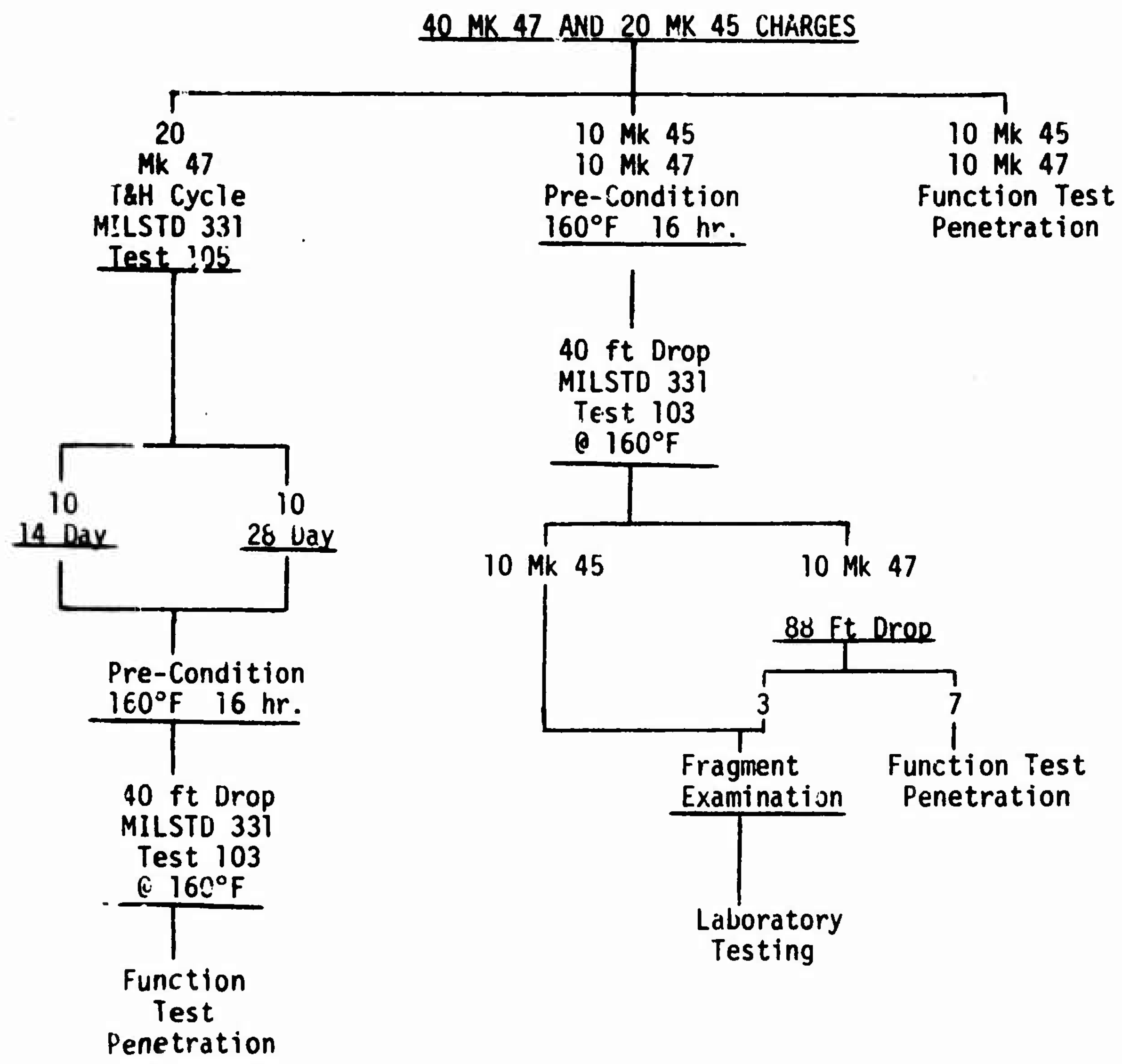

40 MK 47 AND 20 MK 45 CHARGES
20
Mk 47
T&H Cycle
MILSTD 331
Test 105
10 Mk 45
10 Mk 47
Pre-Condition
160°F 16 hr.
10 Mk 45
10 Mk 47
Function Test
Penetration
40 ft Drop
MILSTD 331
Test 103
@ 160°F
10
14 Day
10
28 Day
10 Mk 45
10 Mk 47
88 Ft Drop
Pre-Condition
160°F 16 hr.
3
7
Fragment
Examination
Function Test
Penetration
40 ft Drop
MILSTD 331
Test 103
@ 160°F
Laboratory
Testing
Function
Test
Penetration

FIGURE 2

RDX AND RUBBER ADHESIVE ON MK 47 CONE

FIGURE 3

EPOXY AND DISCOLORATION OF MK 47 RDX

FIGURE 4

MK 47 CHARGES AFTER DROP SERIES

FIGURE 5

MK 47 CHARGES AFTER DROP SERIES

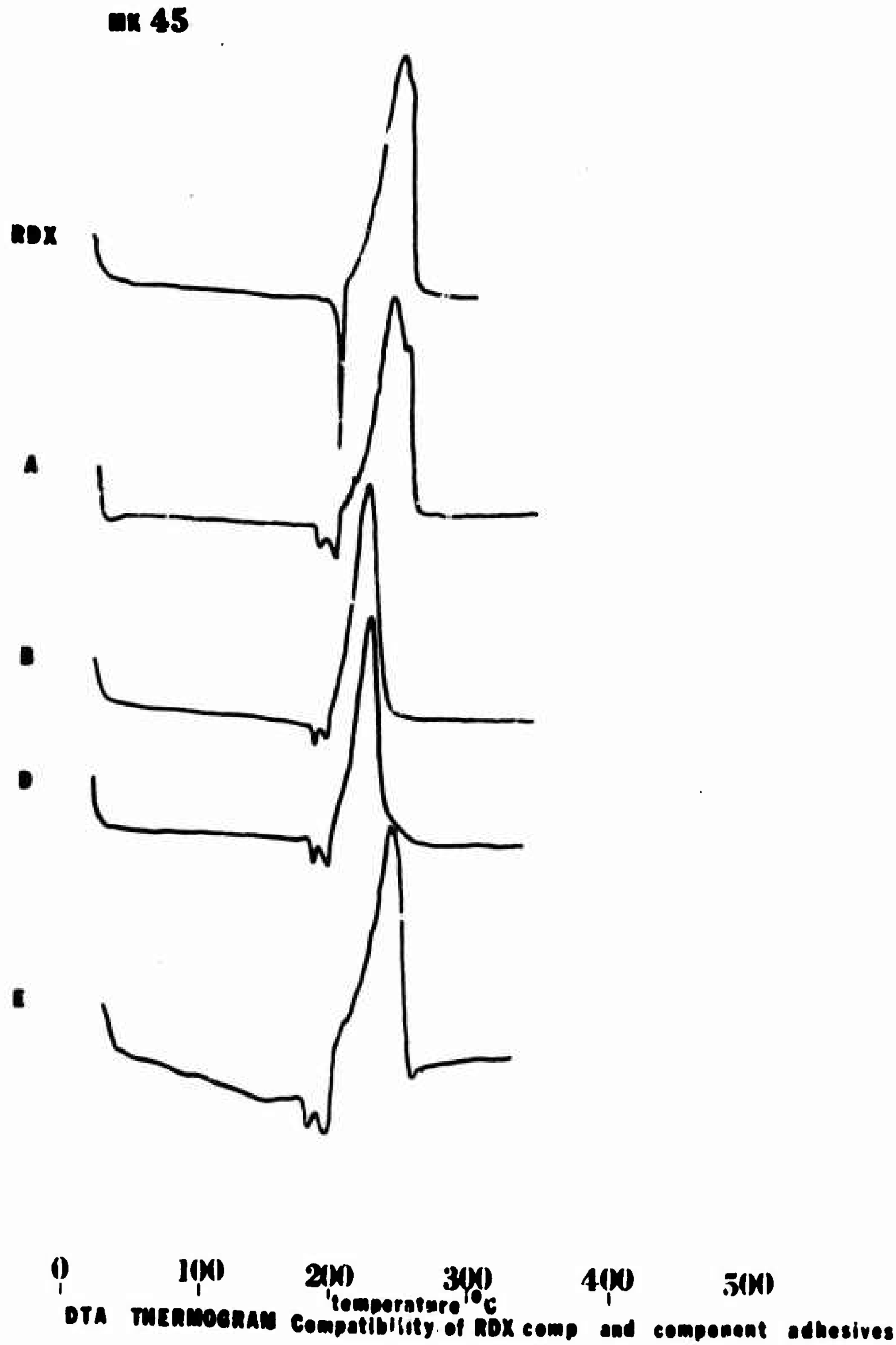
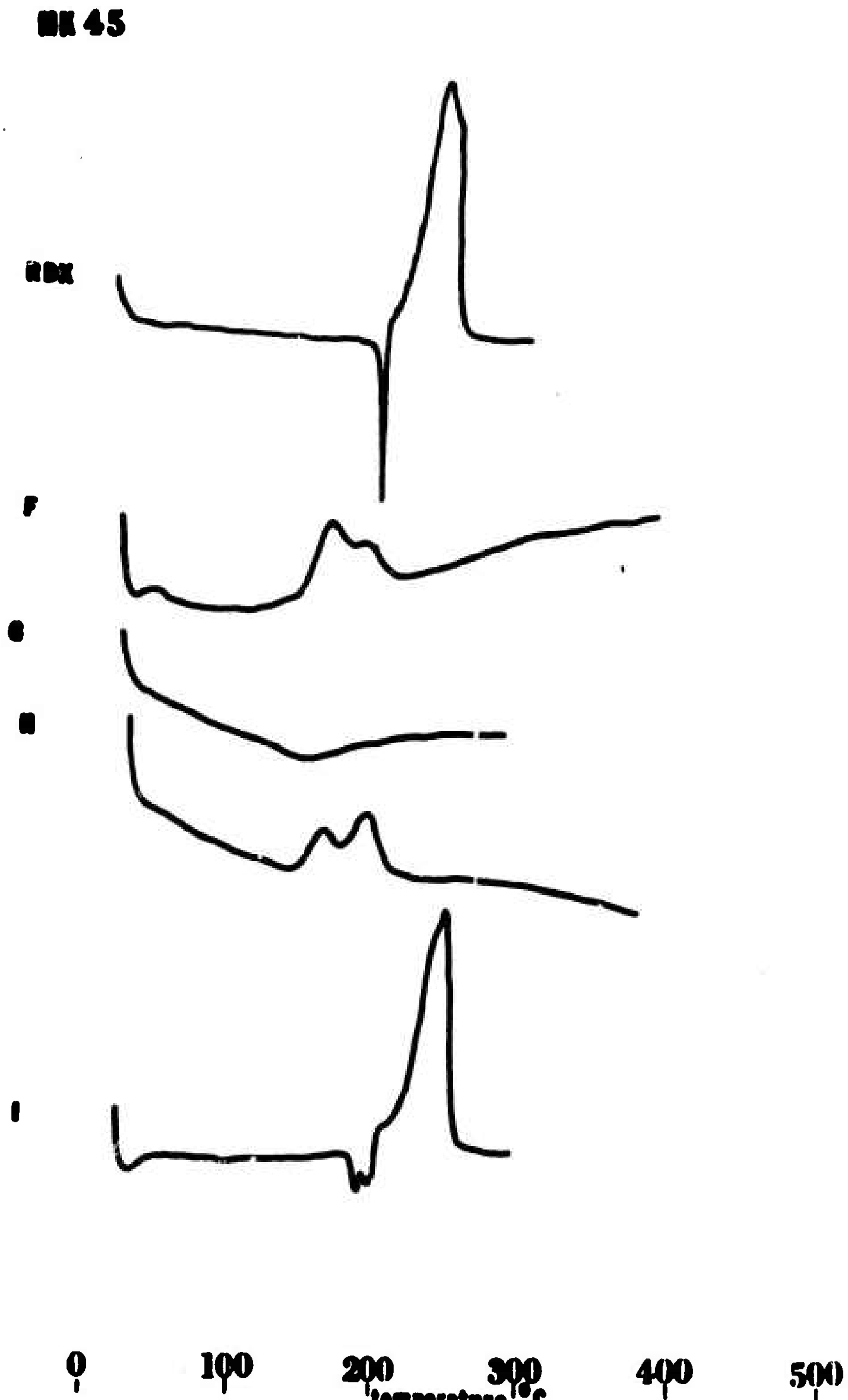


FIGURE 6

MK 45 SAMPLES DTA CURVES



DTA THERMOGRAM Compatibility of RDX comp and component adhesives

FIGURE 7

MK 45 SAMPLES DTA CURVES

MK 47

DTA THERMOGRAM Compatibility of RDX comp and component adhesives

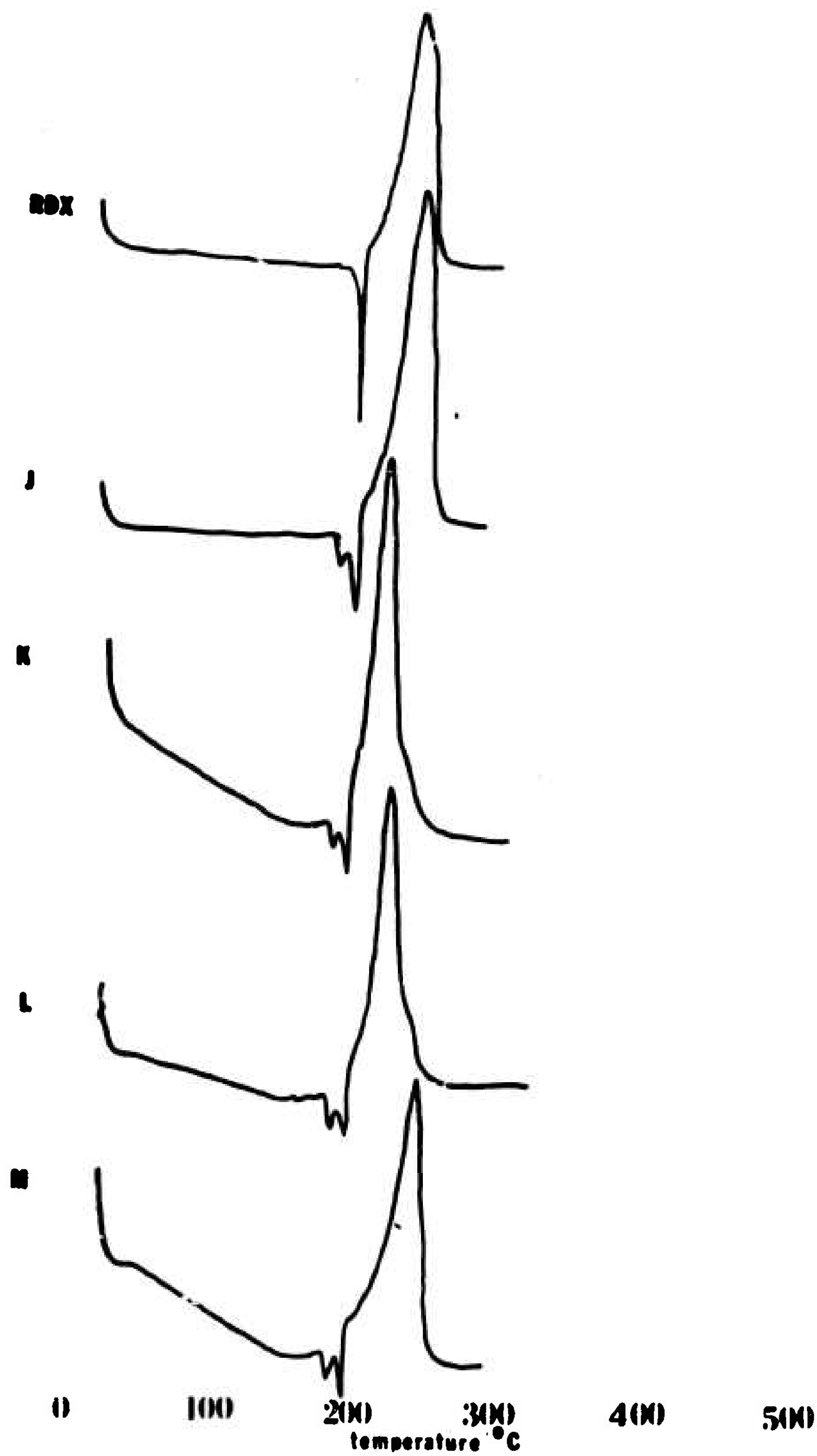
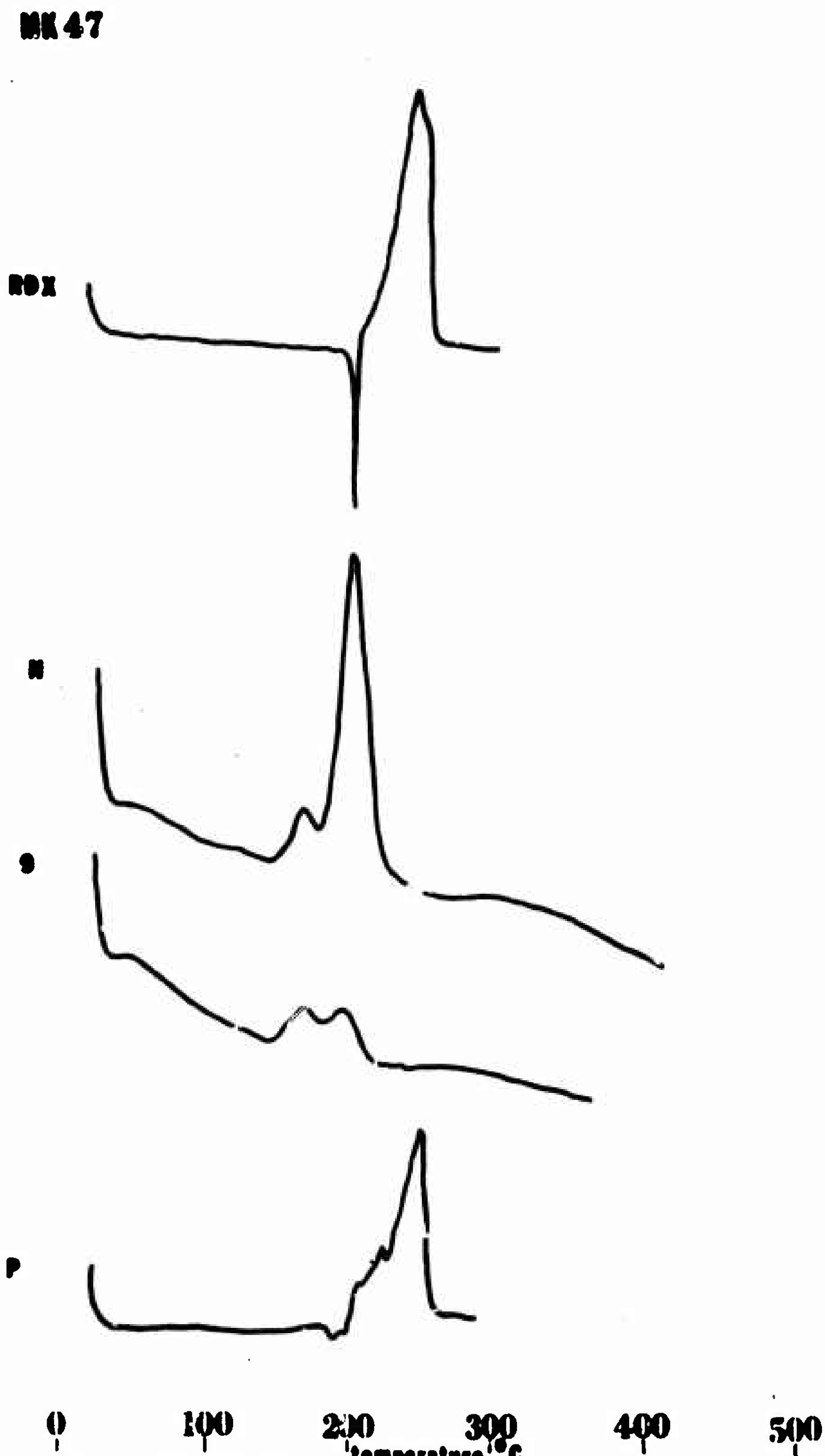


FIGURE 8

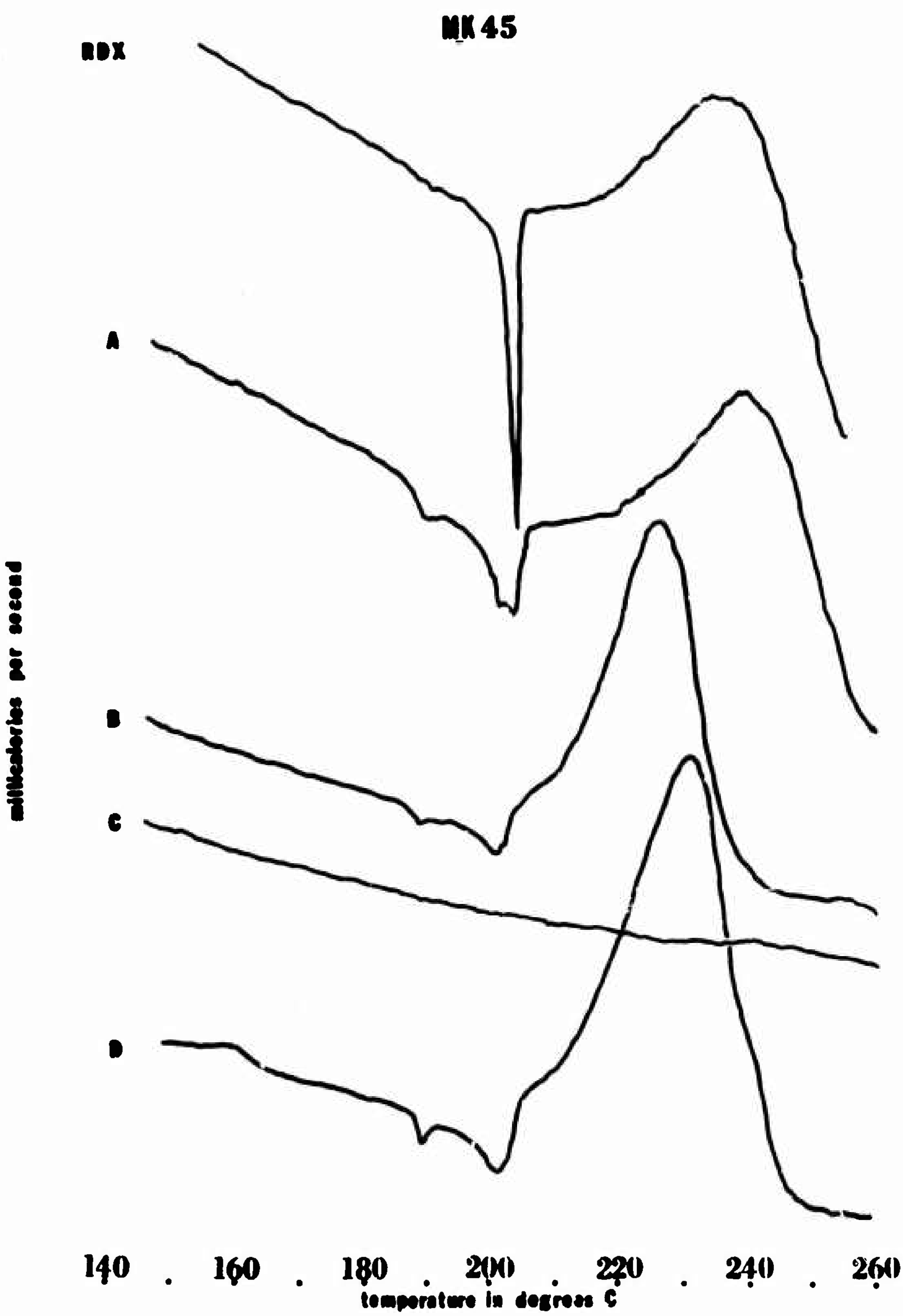
MK 47 SAMPLES DTA CURVES



DTA THERMOGRAM Compatibility of RDX comp and component adhesives

FIGURE 9

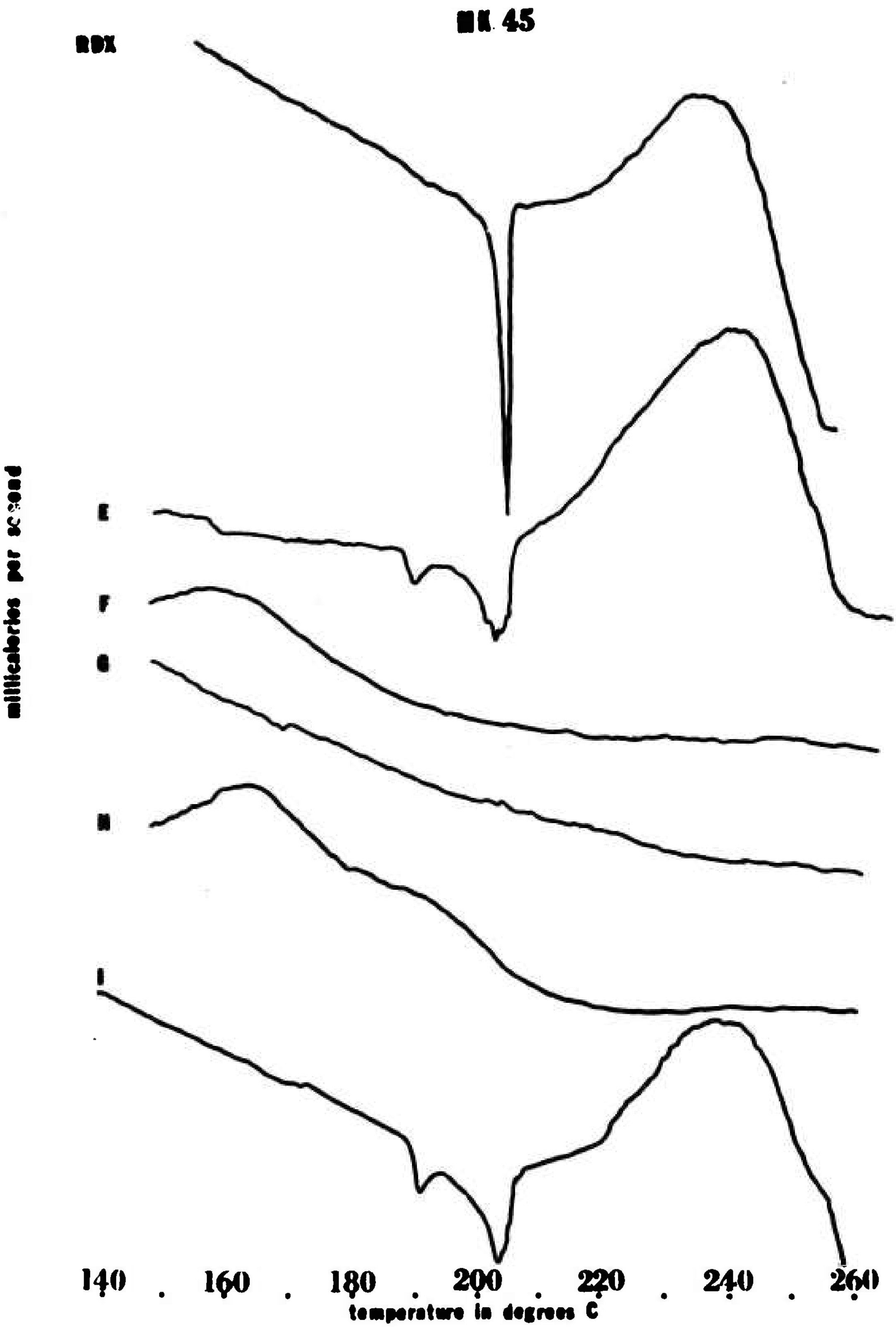
MK 47 SAMPLES DTA CURVES



DSC THERMOGRAM Compatibility of RDX comp and component adhesives

FIGURE 10

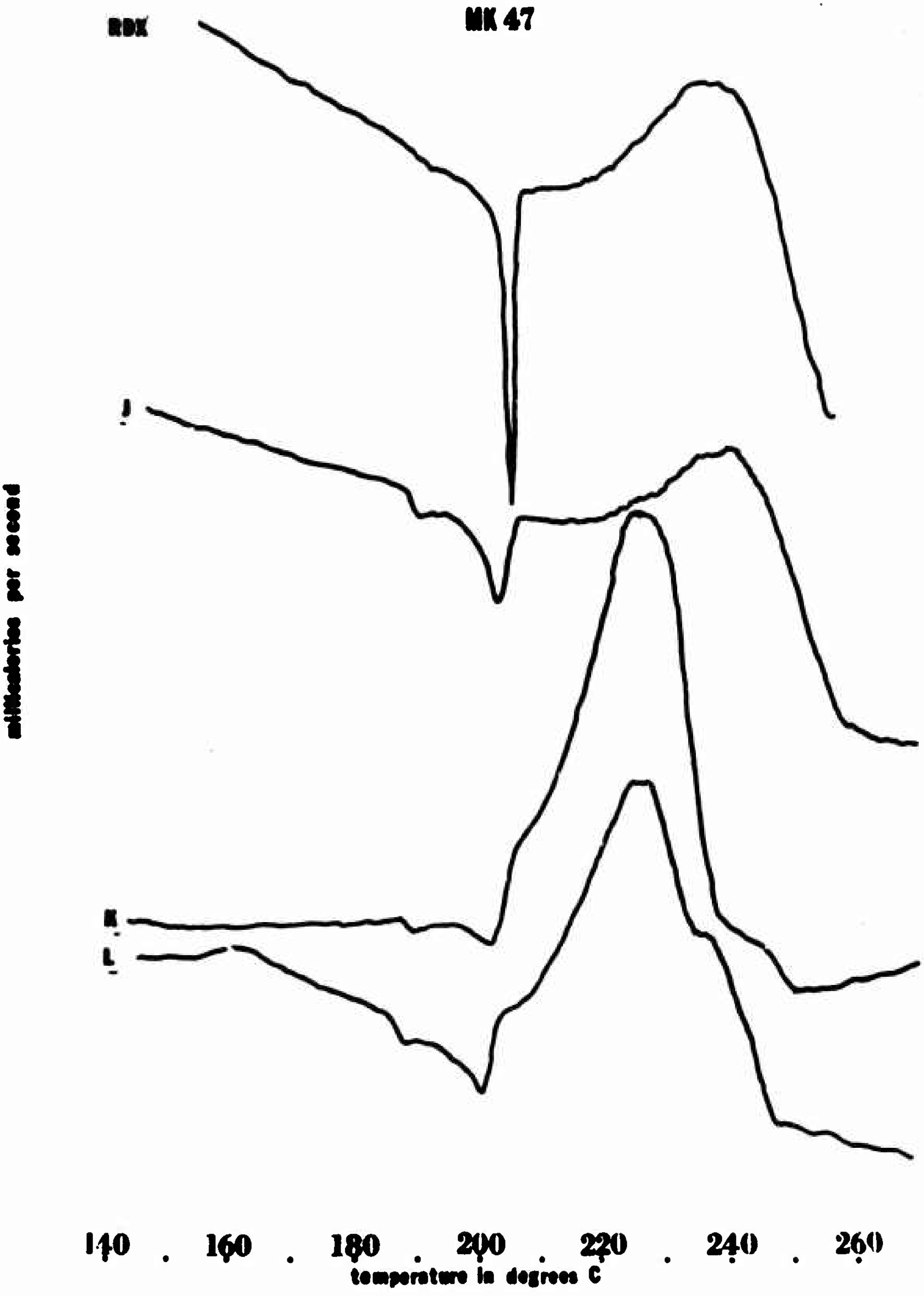
MK 45 SAMPLES DSC CURVES



DSC THERMOGRAM Compatibility of RDX comp and component adhesives

FIGURE 11

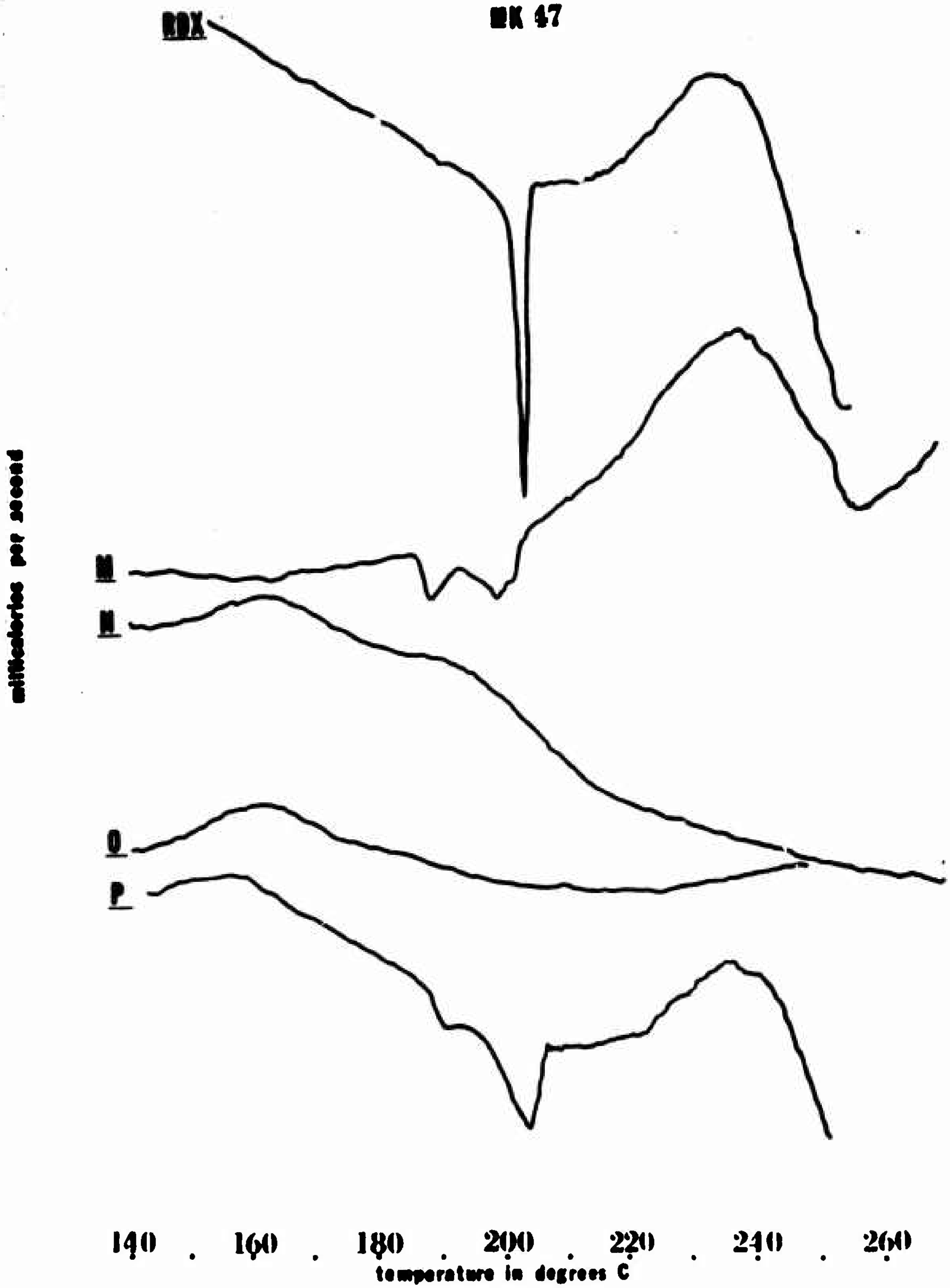
MK 45 SAMPLES DSC CURVES



DSC THERMOGRAM **Compatibility of RDX comp and component adhesives**

FIGURE 12

MK 47 SAMPLES DSC CURVES



DSC THERMOGRAM Compatibility of RDX comp and component adhesives

FIGURE 13

MK 47 SAMPLES DSC CURVES

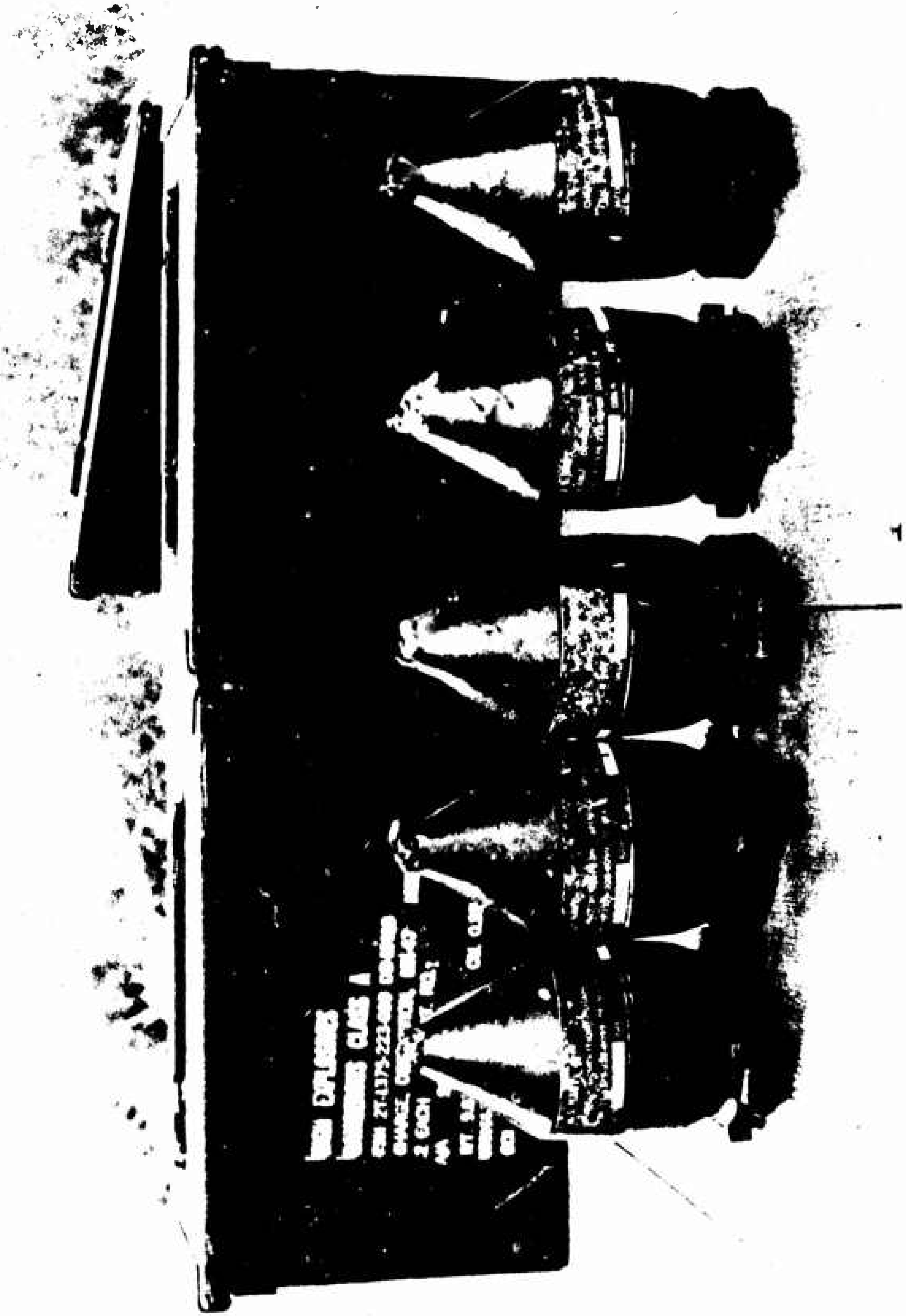
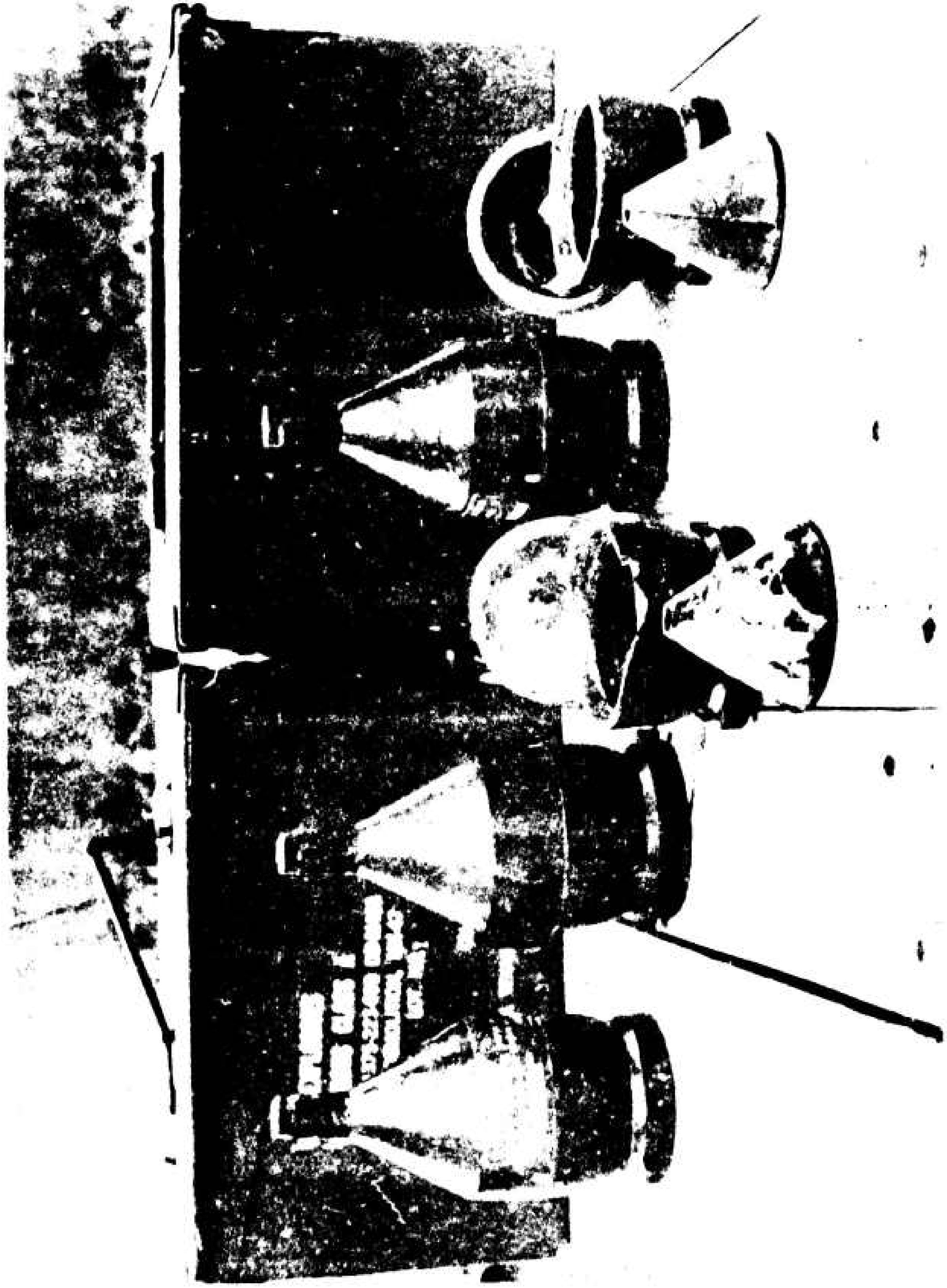


FIGURE 14

MK 47 CHARGES AFTER 28 DAY T&H - SAFETY SERIES



...RGES AFTER 28 DAY T&H -
...TES

AFTER

24

TABLE 1

MK 45 AND MK 47
SHAPED DEMOLITION CHARGE

LABORATORY TESTING

SCHEDULE

Code	Material Sample	TESTS Impact Sensitivity	Vacuum Stability	DTA	DSC
A	Mk 45 RDX Composition with original MIL-A-5072	X	X	X	X
B	50-50 Mixture A & C	X	X	X	X
C	New MIL-A-5072 Rubber Adhesive	-	X	X	X
D	50-50 Mixture E & C	X	X	X	X
E	Mk 45 RDX Composition without contamination	X	X	X	X
F	50-50 Mixture E & G	X	X	X	X
G	New A-12 Epoxy	-	X	X	X
H	50-50 Mixture I & G	X	X	X	X
I	Mk 45 RDX Composition with original A-12	X	X	X	X
J	Mk 47 RDX Composition with original MIL-A-5072	X	X	X	X
K	50-50 Mixture J & C	X	X	X	X
L	50-50 Mixture M & C	X	X	X	X
M	Mk 47 RDX Composition without contamination	X	X	X	X
N	50-50 Mixture M & G	X	X	X	X
O	50-50 Mixture P & G	X	X	X	X
P	Mk 47 RDX Composition with original A-12	X	X	X	X
Q	50-50 Mixture of Copperdust & J	X	-	-	-

TABLE II

MK 45 AND MK 47 SHAPED DEMOLITION CHARGE

SAFETY DROP SERIES

Unit	Mk	Condition After 40 ft. Drop	Second Drop Height	Condition After 2nd Drop	Penetration (in)	Hole
1	47	Intact	88 ft.	Broke Apart	-	
2	47	Intact	88 ft.	Holder broke off	6.10	OK
3	47	Intact	85 ft.	Holder broke off	7.88	OK
4	47	Intact	88 ft.	Holder broke off	7.38	OK
5	47	Intact	88 ft.	Broke Apart	-	
6	47	Intact	88 ft.	Case Cracked & Holder broke off	3.55*	Irregular
7	47	Intact	88 ft.	Intact	6.80	OK
8	47	Intact	88 ft.	Case Cracked & Holder	4.97*	Irregular
9	47	Intact	88 ft.	Broke Apart	-	
10	47	Intact	88 ft.	Intact	3.76*	Irregular
101	45	Intact	60 ft.	Broke Apart		
102	45	Broke Apart	-			
103	45	Intact	60 ft.	Broke Apart		
104	45	Broke Apart	-			
105	45	Broke Apart	-			
106	45	Intact	60 ft.	Broke Apart		
107	45	Intact	60 ft.	Broke Apart		
108	45	Broke Apart	-			
109	45	Broke Apart	-			
110	45	Broke Apart	-			

* The irregularity of the hole and the low penetration depth indicate the cone was damaged or deformed. Penetration depth not included in average for grouping.

TABLE III

MK 45 AND MK 47
SHAPED DEMOLITION CHARGES

SAMPLE	50% FIRE HEIGHT (cm)	13	16	20	25	32	40	50	63	79	100	126
		IMPACT SENSITIVITY FREQUENCY DISTRIBUTION (FIRES/NO FIRES) HEIGHT cm.										
A	45	-	-	-	0/1	1/5	5/11	12/7	8/0	-	-	-
B	76	-	-	-	-	-	0/1	1/7	6/12	11/16	6/0	-
C	-	-	-	-	-	-	-	-	-	-	-	-
D	38	-	-	0/1	1/5	5/7	7/9	9/2	2/1	1/0	-	-
E	42	-	-	-	0/1	1/10	10/9	9/5	5/0	-	-	-
F	33	-	-	0/3	3/9	9/6	7/6	7/0	-	-	-	-
G	-	-	-	-	-	-	-	-	-	-	-	-
H	41	-	-	-	0/1	1/8	8/15	15/1	1/0	-	-	-
I	34	-	-	0/4	4/8	8/7	7/5	5/1	1/0	-	-	-
J	35	-	-	0/1	1/5	5/12	13/6	7/0	-	-	-	-
K	33	-	-	0/3	3/8	8/8	7/5	4/2	2/0	-	-	-
L	33	-	-	-	0/11	12/10	11/3	3/0	-	-	-	-
M	35	-	-	0/1	1/6	6/12	12/5	5/1	1/0	-	-	-
N	37	-	-	0/2	2/3	3/9	9/11	11/0	-	-	-	-
O	91	-	-	-	-	-	-	-	0/1	1/21	21/3	3/0
P	30	0/1	1/2	2/2	2/7	7/9	9/4	4/0	-	-	-	-
Q	45	-	-	-	-	0/3	3/18	18/4	4/0	-	-	-
STD Tetryl	31,27,28											
STD TNT	36,37											
STD RDX	25											

TABLE IV

MK 45 AND MK 47
SHAPED DEMOLITION CHARGE

VACUUM STABILITY

Sample	Gas Evolved (Triplicate Runs) ml/g/48 hrs.
A	0.5, 0.8, 1.0
B	1.4, 1.2, 2.0
C	3.9, 2.3, 4.5
D	0.2, 1.3, 1.3
E	0.8, 0.7, 0.6
F	43, 40, 39
G	- - - - - - - - *
H	33, 34, 34
I	1.1, 0.4, 1.0
J	0.8, 0.8, 0.6
K	2.9, 0.6, 0.6
L	-0.6, 0.6, 0.6
M	-0.1, 0.6, 0.5
N	- - - - - - - - - *
O	- - - - - - - - - *
P	1.4, 0.4, 1.5
Q	0.6, 0.9, 0.6

* Samples not tested due to the excessive gas evolved by similar samples, F & H.

TABLE V

MK 45 AND MK 47
SHAPED DEMOLITION CHARGE

HEAT OF DECOMPOSITION IN CALORIES PER GRAM OF SAMPLE

Standard RDX	905
A	918
B	1652
C	-
D	1933
E	993
F	518
G	-
H	725
I	721
J	629
K	1812
L	1976
M	829
N	950
O	486
P	546

TABLE VI

MK 45 AND MK 47
SHAPED DEMOLITION CHARGE

TEMPERATURE AND HUMIDITY - DROP SERIES

Unit	MK	Pre-Conditioning	Condition After 40 ft. Drop	Penetration (in)	Hole
11	47	14 day T&H Cycle	Broke Apart	-	
12	47	14 day T&H Cycle	Intact	3.25 *	Irregular
13	47	14 day T&H Cycle	Holder Broke Off	7.10	OK
14	47	14 day T&H Cycle	Holder Broke Off	7.45	OK
15	47	14 day T&H Cycle	Broke Apart	-	
16	47	14 day T&H Cycle	Intact	7.55	OK
17	47	14 day T&H Cycle	Intact	7.53	OK
18	47	14 day T&H Cycle	Intact	6.48	OK
19	47	14 day T&H Cycle	Intact	7.75	OK
20	47	14 day T&H Cycle	Holder Broke Off	7.33	OK
21	47	28 day T&H Cycle	Holder Broke Off	7.58	OK
22	47	28 day T&H Cycle	Holder Broke Off	7.48	OK
23	47	28 day T&H Cycle	Holder Broke Off	7.36	OK
24	47	28 day T&H Cycle	Holder Broke Off	7.54	OK
25	47	28 day T&H Cycle	Holder Broke Off	**	
26	47	28 day T&H Cycle	Intact	7.47	OK
27	47	28 day T&H Cycle	Intact	7.33	OK
28	47	28 day T&H Cycle	Broke Apart	-	
29	47	28 day T&H Cycle	Intact	4.15*	Irregular
30	47	28 day T&H Cycle	Broke Apart	-	

* The irregularity of the hole and the low penetration depth indicate the cone was damaged or deformed. Penetration depth not included in average for grouping.

** Detonating cord broke off top of charge case.

TABLE VII

MK 45 AND MK 47
SHAPED DEMOLITION CHARGE

CONTROL TESTS

Unit	MK	Penetration (in)
31	47	7.61
32	47	7.36
33	47	7.93
34	47	7.33
35	47	7.54
36	47	7.61
37	47	7.50
38	47	7.37
39	47	7.77
40	47	7.90
111	45	4.62
112	45	4.47
113	45	4.73
114	45	4.73
115	45	4.74
116	45	4.64
117	45	4.44
118	45	4.44
119	45	4.35
120	45	4.40

TABLE VIII

MK 45 AND MK 47
SHAPED DEMOLITION CHARGE

GROUPED DATA

Mk	Test	Qty	Average Penetration (in)	Quantity	
				Functional	Satisfactory
45	Control	10	4.56	10	10
45	Drop Series	10	-	--	--
47	Control	10	7.59	10	10
47	Drop Series	10	7.04	7	2
47	14 day T&H Drop	10	7.31	8	6
47	28 day T&H Drop	10	7.46	7	6